Multiscale Sensor Networks For Border Security

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Committee on Science

Prof. Greg Pottie
pottie@icsl.ucla.edu
http://cens.ucla.edu

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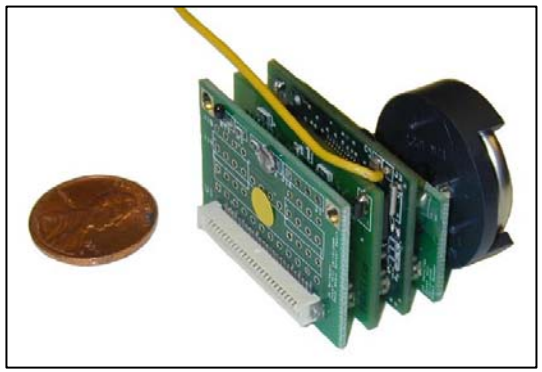
Early Sensor Nodes

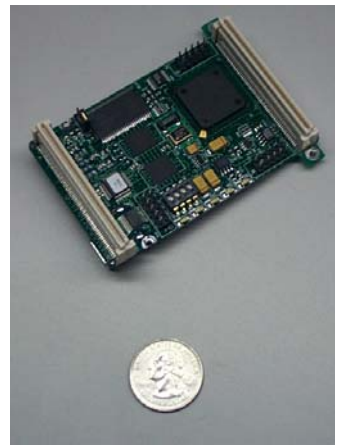
LWIM III
UCLA, 1996
Geophone, RFM radio, PIC, star network

AWAIRS I
UCLA/RSC 1998
Geophone, DS/SS Radio, strongARM, Multi-hop networks

Sensor Mote
UCB, 2000
RFM radio, PIC

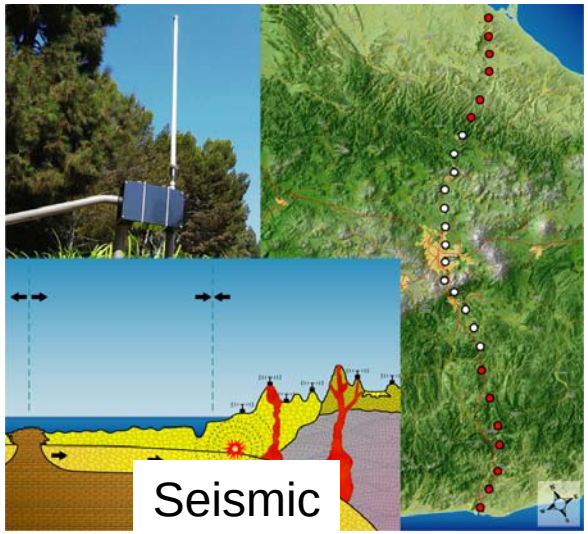


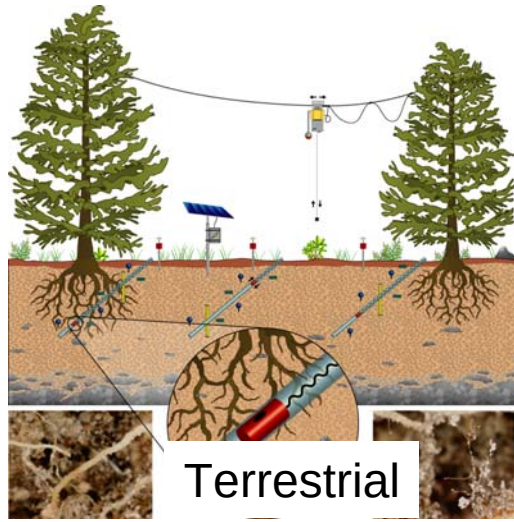
WINS NG 2.0
Sensoria, 2001
Node development platform; multi-sensor, dual radio, Linux on SH4, Preprocessor, GPS



Processor

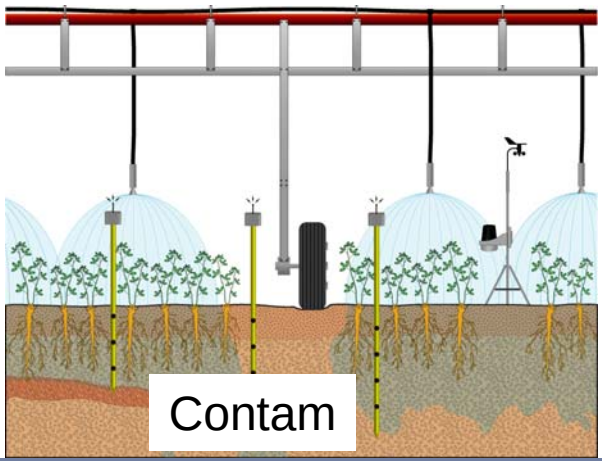
Sensing at CENS

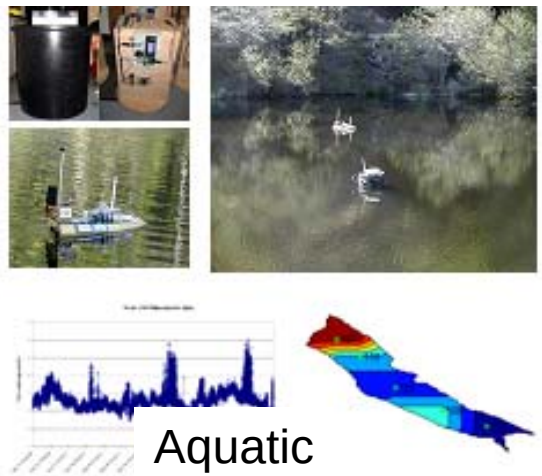




create *programmable, autonomous, distributed, multi-modal, multi-user,* observatories to address compelling science and engineering issues

…and reveal the previously unobservable..





Lessons

Early themes

–**Thousands of small devices**
- Minimize individual node resource needs
- Exploit large numbers

–**Fully autonomous systems**

–**In-network and collaborative processing for longevity:** optimize communication

New themes

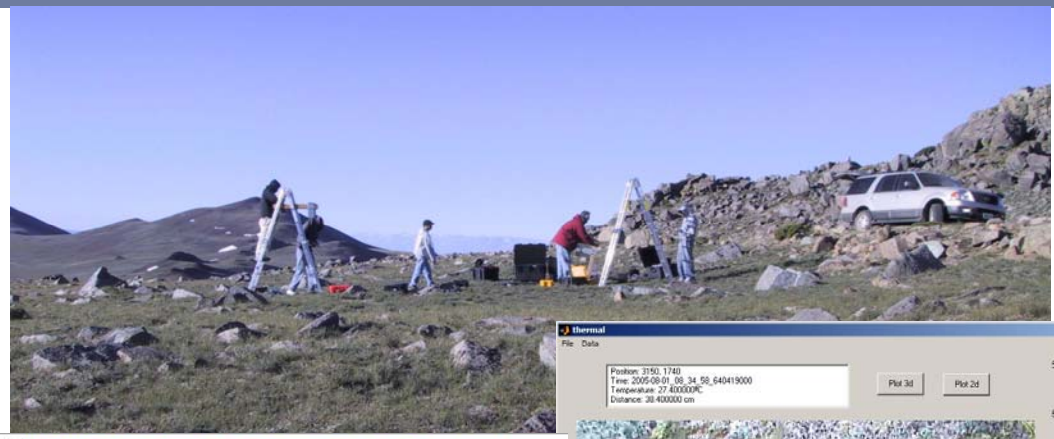
– **Heterogeneous systems**
- Tiered systems: optimize system as a whole
- Inevitable under-sampling (in time or space)
- Exploit multiple modalities (including actuation) and multiple scales

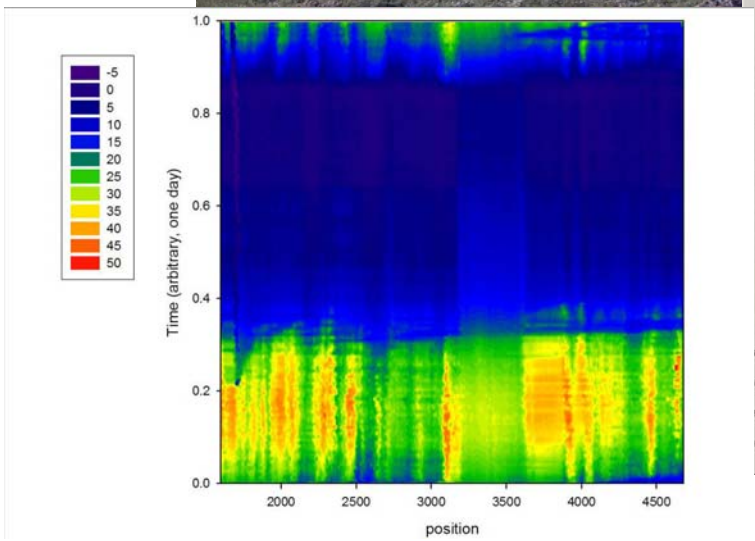
– **Interactive systems**
- Design for human tier as well

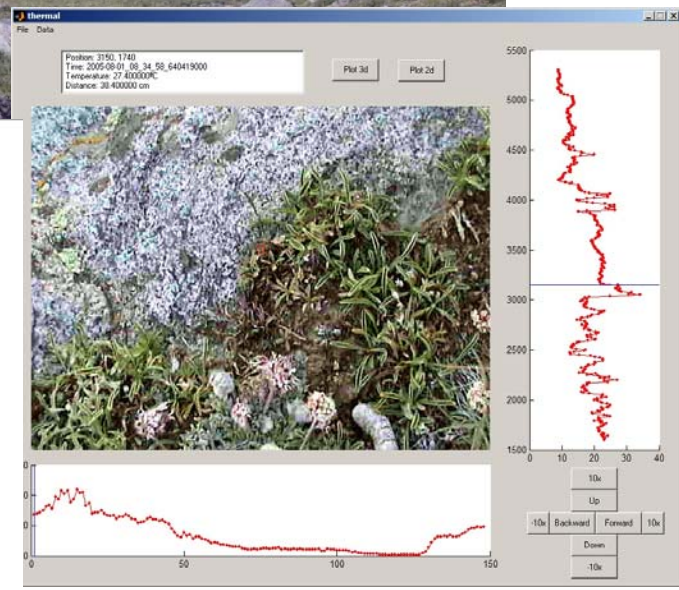
– **In-network and collaborative processing for responsiveness, data quality, and data control (privacy):** optimize sensing

Example: White Mountains Deployment

- Development and deployment of NIMS RD with active roles by domain scientists at all stages







- Tight coordination with end-users is essential for effective design

SITEX: Data collection for SensIT Program

- SITEX August 2000 at MGAGCC 29 Palms, CA
  - 37 Nodes
  - Operating for 2 weeks

Courtesy of Sensoria Corp.

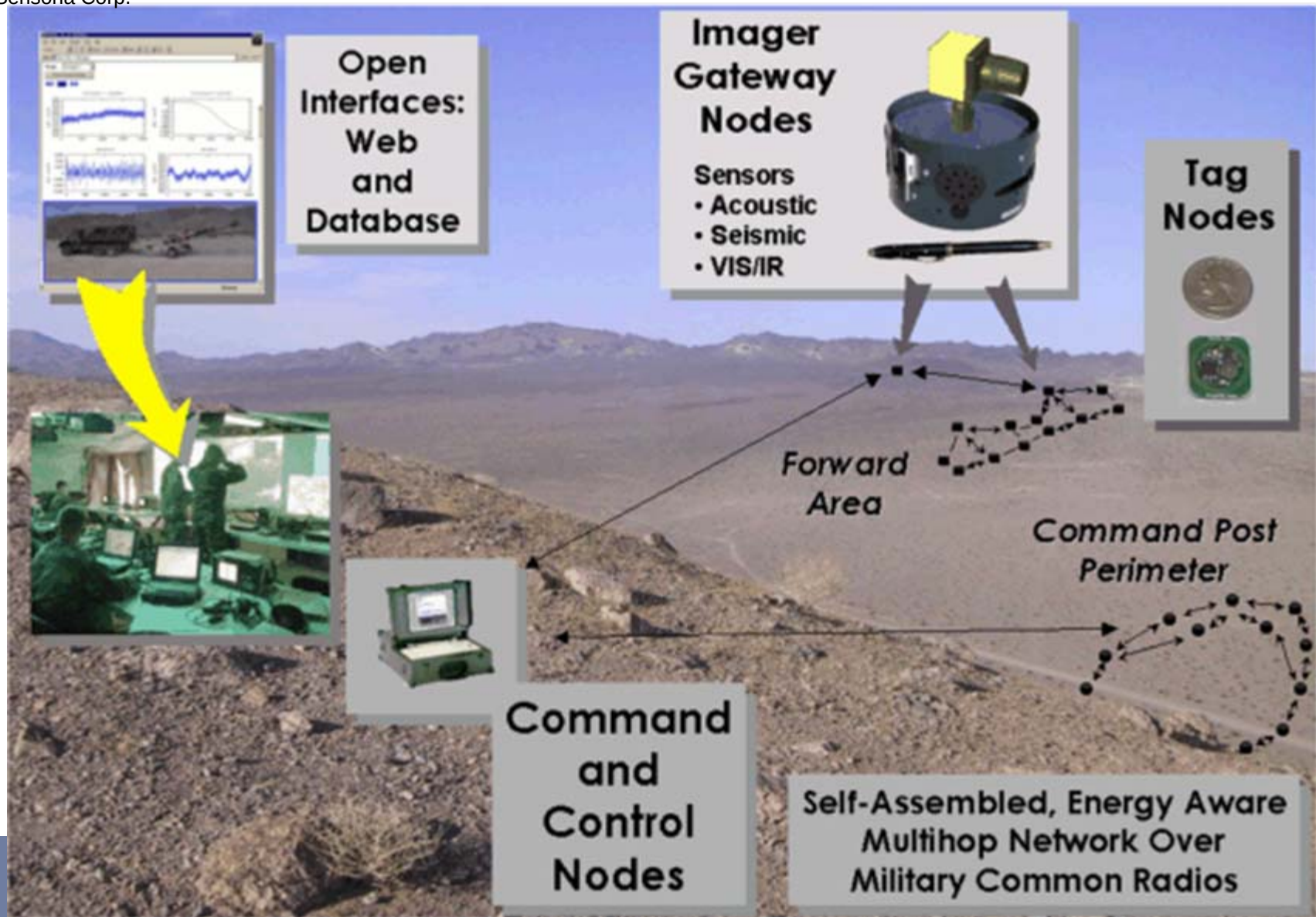
AAV Traveling North to South

- SenseIT Sitex2000 data drives a java GUI
  - AAV in red
  - Nodes in white
  - Green circles are detections
    - Acoustic are magenta dots
    - Seismic are cyan dots
    - IR are blue dots

Courtesy of Sensoria Corp.

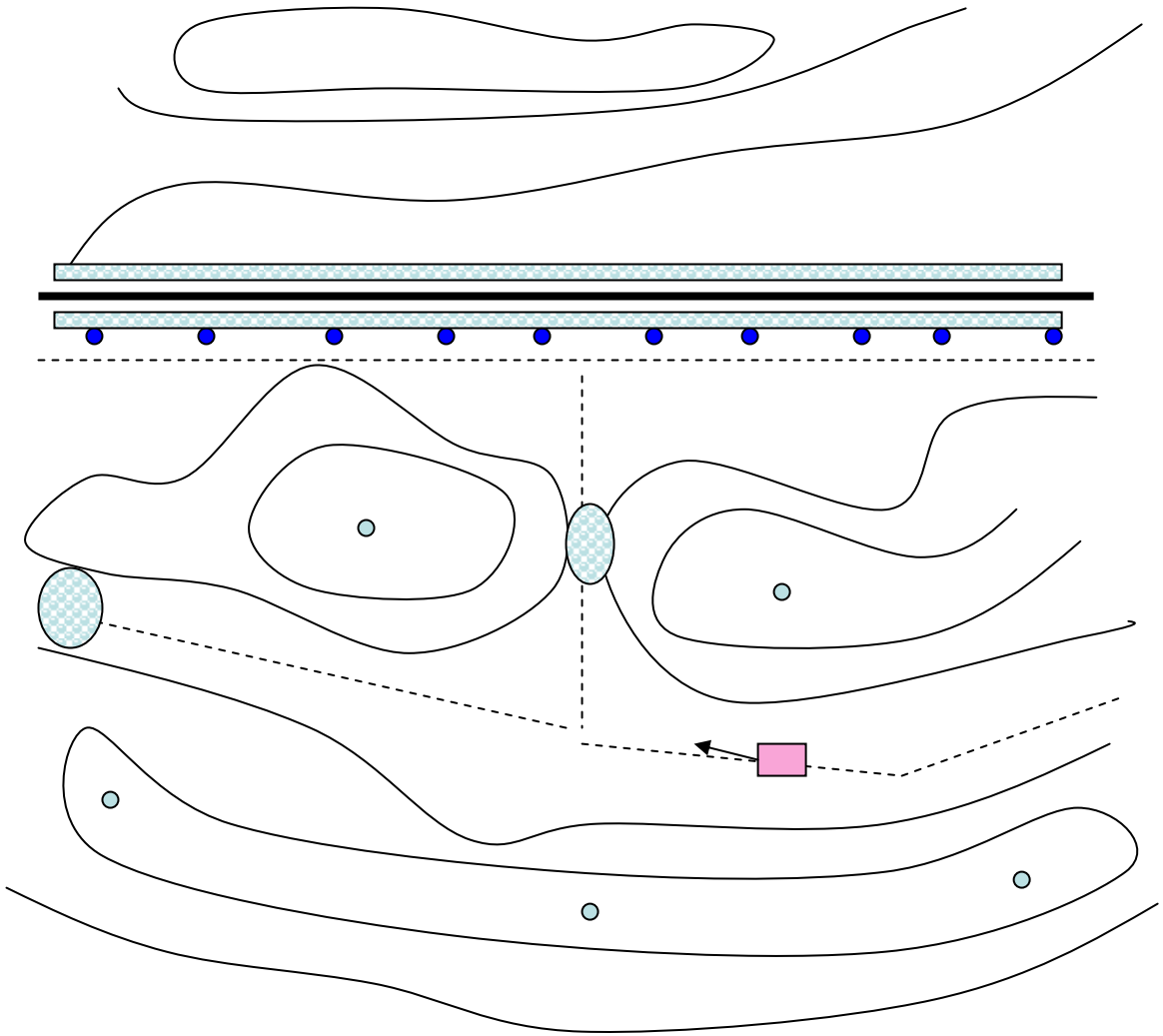
Heterogeneous Detection Network

Courtesy of Sensoria Corp.



Border Security

- Ground vehicle
- Ground sensor field
- Short range camera
- Long range camera/ communication relay



Conclusions

- People/animals are difficult to reliably sense in outdoor environments with acoustic/seismic/IR sensors
  - Many confounding effects
  - Difficult calibration issues
- Cameras/IR arrays required, with humans making decisions
  - Goal of processing and simple sensors is to reduce number of humans required, and trigger attention on interesting things
- Redundancy and detection in depth is required
  - Sensors will malfunction
  - Choke points for vehicles can be intensely monitored
    - Trusted vehicles can have transponders for ease of ID
- Work closely with Border Patrol for system design
  - Design must be an iterative process, in which agents play major role in determination of components/placement/interfaces

References

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